In response to Dockets ET 03-104 and 04-37 (NPRM 04-29A1) before the Federal Communications Commission.

Before I begin addressing my concerns in this action, a few words about my qualifications and perspective seem to be in order. I am a degreed physicist, professionally a radio design engineer for Rockwell Collins, Inc., an amateur radio operator since 1976 (currently W4ATM), and a lifetime shortwave radio listener. As such, I have extensive hobby experience with HF radio and professional experience in the design of HF radio for civil aeronautics. My design specialty is receiver design. I have experience with the measurement of radio emissions to comply with FCC rules. My direct experience is not with part 15, but I have a practical understanding of the problems of testing these fields.

I am writing as an individual, not as a representative of Rockwell Collins or any other organization.

It is my experience in industry that when a category of emissions standards is required, the system is tested and tweaked until the testing authority believes it passes. The designers of BPL equipment will not pay to exceed their requirements by a large margin. I have seen effects on very well-calibrated equipment in professional (FCC Certified) test facilities where simply repositioning a device under test causes quadrupling of its emissions – or even as much as a tenfold increase in its emissions. Practically, if the FCC mandates that the emissions from the Access BPL is to meet the part 15 requirements, it will start shipping when someone believes it is acceptable and is willing to sign the papers. This will have the effect of bathing the United States in a part 15 field.

It is my belief that the part 15 limits proposed for Access BPL are much too high and that not regulating them to lower levels will lead to impairment of many services currently licensed and operating legally under FCC rules. The measurement procedures specified are misleading and will contribute to the problem. The interference can be predicted with simple math models that have been verified countless times, and should not be subject to debate. I would like to address a few paragraphs by number from the NPRM.

Paragraph 33. You begin, "As indicated above, the commenting parties strongly disagree on the interference potential of Access BPL." and go on to discuss that you believe the problems will be solved by having parties who are interfered with complain to the interfering parties so that interference can be mitigated. This misses the point that you are regulating (and thereby creating) the interference field. You say, for example, that BPL proponents believe that higher levels can be allowed but show no mathematical models or empirical results to substantiate that claim. The interference expected should not be a matter of philosophical debate; it is a matter of physics. If you regulate the field emissions so that they meet part 15, that means the field strength measured 30 meters from the source will be 30 microvolts per meter (between 1.7 and 30 MHz). It may be less than that (and based on my experience with measurements, it could well be more) but we should not count on that. **You** are defining the environment.

An isotropic antenna in a field of 30 microvolts per meter at 7 MHz will produce a signal at the antenna terminals of -64.5 dBm. The antenna power will be roughly 6 dB higher at 3.5 MHz and 6 dB lower at 14 MHz. If these numbers do not shock you, they are roughly 20,000 times stronger than the low level signals that the radio can comfortably detect. That interference field will make amateur radio and shortwave monitoring impossible except for all but the strongest signals. This will have catastrophic effects on disaster communications that rely on amateur participation. If the Access BPL system is near a maritime service station, it will prevent maritime distress calls from being heard. If it is near an aeronautical ground station, it will reduce aviation safety. It will need to be quite literally hundreds of miles from a radio astronomy installation to not affect it. Furthermore, this is based simply on the field being compliant with part 15, and does not require the radiator be a point source, as discussed in paragraph 36.

This model and the effects on HF communications have been verified with actual BPL systems by the ARRL in Virginia, the JARL in Japan, and the RSGB in Great Britain; in the Netherlands, Finland, and Austria. The tapes are available for anyone to watch and listen to. This is not make-believe or alarmism, it is simple physics that these problems will be there.

How far away must a BPL point source with part 15 emissions be so that the noise reaches background? For every doubling of distance, the interference will drop 6 dB (1/4 power) because of the inverse square law. That means that at 7 MHz, a typical HF station's receiver will have the interference above the noise level if a BPL point source is within approximately 4 km (2.4 miles) of the station. A complicating factor in determining the distance at which interference occurs is the modulation type used. The amplitude modulated and suppressed carrier modes used in the HF spectrum will be more affected than an FM system, typically used at higher frequencies. This interference distance assumes AM or SSB.

It seems an unavoidable law of modern life that all new rules have unintended consequences. A possible consequence of allowing BPL is that amateurs will increase their powers to the "legal limit" to overcome the noise. This will increase other RFI problems and increase the likelihood of damage to the BPL system from the increased fields it is exposed to. In tests documented by the AMRAD, 4 Watts from an amateur mobile station was sufficient to prevent a BPL system from passing data. Unlicensed CBs put out more power than that.

Paragraph 34. I believe my previous mathematical models address the first part of this paragraph, that the interference will be over small areas. If 2.4 miles from a point source emitter is a small distance and the repeaters in the system are 10 miles apart, perhaps this can be considered a small area. With regard to the second part, "In this regard, we note that hundreds of kinds of unlicensed devices are successfully operating under the current Part 15 limits without causing harmful interference to licensed operations". I would caution that the existing part 15 devices may not be as interference free as you believe. It might simply be that the parties interfered with have not been able to isolate the offending device. Isolating an interfering device can take a great deal of detective work, and when it has been found all parties are losers. The person with the device lost the use of it, while the party that experienced the problem lost their time and antagonized a neighbor.

Paragraph 35. You note that amateur operations will be difficult to accommodate, but then make the statement, "We therefore would expect that, in practice, many amateurs already orient their antennas to minimize the reception of emissions from nearby electric power lines." This is an amazing argument. If I may be allowed to re-phrase it, powerlines are already a problem so it doesn't matter if we make them worse. Why not make powerlines less of a problem? In practice, amateurs can not always orient their antenna to minimize powerline problems. Furthermore, the 30 meter distance at which the Part 15 E-field is specified is on the order of the size of a suburban lot. It will not be possible for amateurs living in a housing development or in apartments to get their antenna far enough away from the emitters to reduce the field.

Paragraph 36. You say, "Although we agree with ARRL that Access BPL on overhead lines is not a traditional point-source emitter, we do not believe that Access BPL devices will cause the power lines to act as countless miles of transmission lines all radiating RF energy along their full length." In one sense, it appears to me to be a textbook example of an end-fed wire, and amateurs have used these as antennas since the days of the Zeppelins - we call them Zepp antennas. The complicating factor will be the distributed radiators. You go on to say that these distributed radiators, the transmitters, repeaters and so on, will be the major source of emissions which is likely true, but it seems unlikely that the lines will not contribute. At the least, they will have signal coupled onto them which will then radiate. The radiation from the powerlines will depend on the amount of balance between them; single wires radiate quite well, pairs can be a transmission line that do not radiate if they balance well. The power grid, however, was not designed to be a well balanced transmission line at HF. This is a complicated problem with many variables that could be modeled with an electromagnetics field solver. Wouldn't it be prudent to have an objective, uninvolved party, such as university consultants, carry out extensive computer modeling followed by tests to verify the model?

In the worst case, as a simple approximation, the powerlines could be considered a cylindrical radiator, and will have a 1/R fall off in signal strength instead of the inverse square relationship of a point source. If it does indeed behave this way, there will be interfering fields out to over 500,000 km from a powerline. No place in America will be safe.

Paragraph 37. You say "In general, we believe that a properly designed and operated BPL system will pose little interference hazard to non-amateur services such as aeronautical, maritime and public safety." Why should a BPL system behave differently near one class of station than any other station? Again, if you regulate the emissions field produced to 30 microvolts/meter at 30 meters, such a source placed near a maritime service station will cause just as much interference as it would near an amateur station. It will still produce -64.5 dBm at 7MHz. Signal levels at the maritime fixed installation may be intended to be higher than the signals amateurs typically work with, but will a vessel in distress always put out the anticipated ERP? Will a vessel in distress with a damaged antenna deliver the intended signal? Signals are not always what we intend them to be. If your intent is not to allow the Access BPL equipment near these stations, it is not apparent in this paragraph, or elsewhere.

This underscores the problem of mobile stations. There is no way, with the proposed interference levels, for mobile stations to be protected. The family cruising in a small boat on inland waterways will be affected by powerlines along the shore. The amateur trying to get away from the noise by going mobile, hiking, or to a park, will be victimized by the nearby powerlines.

Paragraph 40. You are placing the burden on the party being interfered with to initiate service to remove the interference, rather than placing the burden on the Access BPL provider to not cause interference in the first place. This is backwards. "First, we are proposing to require that Access BPL systems and devices incorporate capabilities that would allow the operator to modify system performance to mitigate or avoid harmful interference to radio services. Such adaptive interference mitigation techniques would include, for example, the capability to reduce power levels on a dynamic or remote controlled basis, and the ability to include or exclude specific operating frequencies or bands." In the first example you are saying that the party being interfered with must contact the BPL provider, report the frequencies that are being blocked and the provider will then move the frequency. If the HF user then changes their operating frequency and encounters the problem again, they repeat this potentially endless cycle: call the BPL provider; have them move the interference, change channel, call the provider, ad infinitum. In the second phrase, to say "adaptive interference mitigation" raise several interesting (if not terrifying) questions. What exactly is "adaptive interference mitigation"? "Adaptive" implies it adapts to the environment. How will such a system work? Will I have to transmit on a frequency for a while until the BPL system knows I'm trying to use the frequency it is on, before it moves? What if it moves to another frequency I want to use? What if I simply want to listen to the BBC or another shortwave service, and can't transmit? How will it know to avoid the frequency band I want to listen to?

Why is the burden on the individual being interfered with, and not on the interfering BPL provider? If I get in my car, it is my obligation not to drive off the road on to someone's lawns or other properties. It is my obligation not to interfere with someone else's licensed use of their vehicle. I am not free to drive on the sidewalk until someone complains. Why should a BPL provider be allowed to trespass on frequencies legally allocated to other services?

The most reasonable solution is to move the service to where it won't interfere with anybody. As an RF engineer, I would use the 2.4 or 5 GHz bands where most wireless LAN activity is. In the HF spectrum, the frequencies used for diathermy are a reasonable place, but there isn't enough spectrum for them. The spectrum from 30 to 50 MHz appears lightly used and would tolerate the part 15 levels better. The services here are FM and therefore will not be as badly interfered with as the AM and suppressed carrier modes used in the HF spectrum. Even the VHF TV or FM broadcast frequencies will likely cause less problems, as the wide bandwidths of the signals will help protect them. Only fringe areas would be affected.

Paragraph 41. Selective notching of frequencies may have merit, if they manage the rise and fall times of their pulses so that excessive signal spread is not a problem. It is inescapable physics that rise and fall time is inversely proportional to signal bandwidth, so that if they move their transmitter out of band but don't adequately shape their pulses, they will still be audible. But selectively notching out amateur service does nothing for the other services that use HF. If you notch out every service that will be affected, there will be very little bandwidth left. Some licensed service is going to be impacted.

Paragraph 43. The idea of some sort of database of the equipment in usage, where it is, and the pertinent details is a sound idea. The data needs to be available to the public, so that we can help locate defective equipment. Amateurs and shortwave listeners regularly are the first ones to identify faulty utility poles for the interference they cause. A common problem for amateurs and radio hobbyists is to identify a power pole that has a problem and not be able to get the utility to fix it. But this won't happen with BPL will it?

Paragraph 44. Beware of the non-sequitur. You say, "Low-speed carrier current systems, which for a number of years have been operating inside buildings, have rarely been a source of harmful interference to radio communications…," this may be true, but you're comparing apples and oranges. These systems work at frequencies well below the frequencies of the access BPL, where inhabitants of the buildings won't be using radio communications.

Paragraph 45 and Appendix C. I propose a change. Measurements should use an electrical field sensing antenna below 30 MHz as well as a magnetic loop, because the services being interfered with will be using electrical field antennas more often than magnetic loops. Using only magnetic loops may give inappropriately optimistic results. Use the higher measured field of the electric and magnetic measurements for rating the Device Under Test. Moving the antennas down the powerline is a sound idea and may produce surprising results.

Paragraph 46 and Appendix C. I propose two changes. Repeatable and accurate measurement of RF emissions is a difficult task, even in the most well-equipped laboratories. To do so in the field is especially difficult. Below 30 MHz, all of the measurements proposed are in the near field of the source. As you point out, ground reflections will complicate the measurements. Ground reflections will not only come from the ground the technician is standing on, but from trees, fences, buildings and every other object in the field. For this reason, I believe the most accurate measurements will be those made highest above the ground. You propose using slant range and keeping the measuring antenna at 1 to 4 meters above ground. I propose you will get more accurate and repeatable measurements with the measuring antenna at or above the height of the powerline. A typical height might be 7 to 10 meters, depending on the powerline height. There are obvious logistical problems and safety concerns involved here, but it appears these are unavoidable if accurate measurements are to be made. Finally, it is common practice to measure the emissions at 3 meters and extrapolate at 40 dB/decade to obtain the value at 30 meters. This is only valid if you are in the far field of a point source, and one of the things we are trying to measure is whether or not we are dealing with a point source. I propose you either measure at 30 meters or use the more common 20 dB/decade extrapolation.

In conclusion: The action before the FCC is going to establish the interference environment that every licensed service using HF will face. The designers of the BPL equipment will have no economic incentive to design for much lower emissions than those required by law, but the levels are 40 dB too high for HF. If the Commission regulates a part 15-compliant field of 30 microvolts per meter measured at 30 meters, that is what the HF spectrum will eventually become. A BPL system or any widespread system producing such a field has the potential to utterly destroy amateur, maritime, broadcast and other services currently licensed in the HF spectrum. This can be calculated with models any RF engineering student has seen.

As you are well aware, the HF spectrum is fully allocated and busy. In order to allow licensed users to continue to utilize the spectrum they are legally operating on, they must be protected from harmful interference. Because of the widespread use of AM and suppressed carrier modes used at HF, the access BPL emission specification needs to be reduced to from 30 to 1 microvolt/meter at 30 meters to not interfere excessively with existing services. Note that this number does not eliminate interference; it simply drops it to a level closer to the atmospheric noise in the HF spectrum. If this is not acceptable, there are several areas of spectrum that will present fewer interference problems: 30 to 50 MHz, VHF TV channels 2-5, and the FM broadcast band.

Addendum: Calculations

E field to dBm_i

$E := 30\cdot 10^{-6}$ V/m $f := 7\cdot 10^{6}$ Hz

$\lambda := \dfrac{300\cdot 10^{6}}{f}$ meters

$dBmi := 10\cdot \log\left(\dfrac{E^2\cdot\lambda^2\cdot 10^3}{480\cdot\pi^2}\right)$ $dBmi = $ ▮

Antenna input powers from a Part 15 field, decrease in field with distance. The sensitivity of an HF receiver is assumed to be -107 dBm, 1 microvolt in 50 ohms. In actual practice, they are several dB more sensitive than this, but the external noise (atmospherics, etc.) in the HF spectrum can mask this.

Point Source Model

Meters	**dBm at receiver**
30	-64
60	-70
120	-76
240	-82
480	-88
960	-94
1920	-100
3840	-106
7680	-112

Line Source Model

Meters	**dBm at receiver**
30	-64
60	-67
120	-70
240	-73
480	-76
960	-79
1920	-82
3840	-85
7680	-88
15360	-91
30720	-94
61440	-97
122880	-100
245760	-103
491520	-106
983040	-109
1966080	-112